DENISON UNIVERSITY BULLETIN

Volume 42, No. 12

JOURNAL

OF THE

SCIENTIFIC LABORATORIES

Volume 37 **Articles 8-9** **Pages 133 to 163**

EDITED BY

W. C. EBAUGH

Permanent Secretary Denison Scientific Association

GRANVILLE, OHIO

DECEMBER, 1942

The University Bulletin is issued bi-monthly and is entered at the Post Office in Granville, Ohio, as mail matter of the Second Class

JOURNAL OF THE SCIENTIFIC LABORATORIES OF
DENISON UNIVERSITY

The entire file of volumes 1 to 13 was destroyed by fire; no publications issued prior to 1907 are now available. Volumes 14 to date may be obtained from the editor at $2.00 per volume, with the exception of volume 15, the price of which is $1.00. Separate parts, as listed below, may be purchased at the prices indicated.

a

c
t
I
s
r
v
r
i

t
u
'i
b
t

"

d
th
in
be
G
G
to
ill

Yo

GEOGRAPHY IN A WORLD AT WAR*

C. LANGDON WHITE

Received November 11, 1942; published February 2, 1943

INTRODUCTION

By some geography has been defined as the key to today's news—history in the making. Certainly *land* is the basis of international relations. Yet geography is the least understood and the most misunderstood subject in American education. Dr. John W. Studebaker, U. S. Commissioner of Education, recently stated in Baltimore:

> "Apart from rather backward nations, we are more illiterate geographically than any civilized nation I know. There are, of course, a few exceptions in some places, but I mean that by and large we have not taught geography to our citizens. Young people have stopped studying geography in about the seventh or eighth grade of the common school, . . . If we can get out of that policy an intelligent understanding of the world on the part of those taught, I would like to know how to do it. So I would recommend that in some way throughout the secondary schools and in the colleges and universities a real emphasis now be laid upon acquainting the American citizens with the realities of the world through intensive courses in world geography."

A preponderant proportion of our people continues to look upon geography as that dull arid subject consisting essentially of the memorizing of multifarious unrelated facts on the one hand, and of that deadly nausea of 'locate this' and 'bound that' on the other. But it could hardly be otherwise, for "nature has been so silent in her persistent influence over man that the geographic factor in the equation of human development has been overlooked."[1]

There are many definitions of geography. I like to think of the subject as "human ecology" or the mutual relation between man and nature.

THE WAR AND MAPS

The war is making the American people more conscious of maps. Four times did President Roosevelt ask his radio audience on February 23, 1942, to look at their maps of the whole earth. Geography strives to make people more skilled in the use of maps, to enable them to see in maps not merely conventional symbols but permanent physical opportunities. Compared with the situation in Germany, map illiteracy is extraordinarily high in the United States. The Germans use maps at every stage of a youth's education from the kindergarten to the university and claim there is no valid geopolitical theory that cannot be illustrated on a map.

Probably the biggest single lesson to be learned from maps by our "flat earth

* Phi Beta Kappa address at the commencement of Denison University, June 7, 1942.

[1] Semple, Ellen Churchill, *Influences of Geographic Environment*, Henry Holt & Co., New York, 1911.

thinkers" is that the earth is a gigantic spheroid. This understanding is made imperative by the rapid development of aviation, for the shortest distance between two points on a sphere is a great circle on the arc of a bisector. In other words, the shortest distance between two points is the line passing through these points that would cut the sphere in two equal parts. To really understand the significance of the Great Circle Route one must use a globe—the only *accurate* map. Select any two points, as for example Cleveland and Tokyo, and stretch a string tightly over the surface of the globe and the shortest distance between them is obtained. Note that although Tokyo is southwest of Cleveland, the shortest distance to it is northwest from Cleveland across Canada to Fairbanks, Alaska, and then southwestward over the coast of Siberia to Tokyo.

Much of our misunderstanding is due to the improper use of maps—especially the widespread adoption of the Mercator Projection—on which distances are not true. The only reliable source of global understanding for nontechnical people is the terrestrial globe and a piece of string.

GEOGRAPHY AND WAR

War causes peoples to realize their dependence upon the earth. War is above all things a matter of geography, for it is tied to the surface of the earth, it functions only by utilizing the resources of the earth, and it moves purposefully over the earth seeking out those positions favorable to one side and unfavorable to the other side.

IMPORTANCE OF RAW MATERIALS

From the dawn of history nations have differed in their natural endowment and hence in their economic opportunities. Nature did not distribute raw materials equally; thus Canada has 85 per cent of the world's nickel, Greenland all the world's cryolite, and Brazil nearly all of the world's commercial quartz crystal. The continent of South America possesses less than one per cent of the coal of the earth, while Australia and Africa are practically devoid of petroleum. The great industrial nations, those making most of the iron and steel (Russia excepted) have almost no manganese—that metal indispensable to the manufacture of steel. No country is self-sufficient in raw materials. The United States, richest of all, lacks nickel, tin, most of the metals for making ferro-alloys,[2] and many others. It could not build a battleship, an airplane, or even a telephone exclusively from domestic raw materials and do it economically. Therefore, the outcome of any great war, such as the present global struggle, must take into consideration the matter of raw materials.[3] So important are they that the Army and Navy Munitions Board has prepared a list of *strategic* and *critical* raw materials—a list that grows as the war is prolonged.[4]

[2] The ferro-alloys (alloys of chromium, manganese, molybdenum, nickel, tungsten, and vanadium) confer certain properties to steel that it could not have without them.

[3] For the uses of the 30 raw materials most vital in war, see Holmes, Harry N., *Strategic Materials and National Strength*, The Macmillan Co., New York, 1942, pp. 9–11.

[4] Commodities Division, Army and Navy Munitions Board, *The Strategic and Critical Materials*, Washington, March, 1940.

The desire to possess mineral supplies is indisputably a major cause of the present conflict, for industrial expansion is dependent on a continuous and adequate supply of raw materials regardless of origin. Thus nations lacking domestic reserves have stressed their deficiencies in their drive toward economic self-sufficiency.

Eight nations collectively consume annually more than three-fourths of the world output of minerals essential to modern industry. These, prior to the outbreak of the second World War, were divided into two groups—the "haves" and the "have nots."[5] This grouping implies that colonial mineral resources and markets are more readily available to the mother country than to other nations. Nevertheless, the economic advantages of colonies as sources of raw materials and as preferential markets for surplus industrial products may be over-estimated.[6]

All three of the "have nots" have shown a fantastic desire to acquire a "place in the sun." Determined to be *great powers*, but lacking what it takes to become so and lacking adequate funds with which to purchase requirements of raw materials in competitive markets, they decided nevertheless to acquire them. Germany, most important industrially of the three, had inadequate basic resources to meet industrial requirements.[7] Japan's situation was similar to that of Germany except that heavy industries were but slightly developed. Italy, on the other hand, was the poorest of the Great Powers and, though determined to achieve autonomy in the briefest possible time, emphasized the problem of migration more than the lack of raw materials.[8] Italy lacks such resources as iron, tin, copper, chromium, manganese, petroleum, rubber and many others vital to a warring nation.

Today, the tables are turned and Germany and Japan have become "have" powers, and are applying an economic blockade against the United Nations. Italy, however, is far worse off than before she entered the war.

The Anti-Axis nations, on the contrary, control 63, 67 and 78 per cent of the production of the three raw materials most essential for war—iron ore, coal, and petroleum. The United States alone produces about 61 per cent of the world's petroleum and more than a third of the coal and iron ore.[9]

WAR AND CLIMATE

The Summer Monsoon and India.—It is impossible to treat more than casually in this address the rôle of climate, which definitely is a part of geography. Suffice

[5] Staley, Eugene, *Raw Materials in Peace and War*, Council on Foreign Relations, New York, 1937.

[6] *Raw Materials and Colonies*, Information Department Papers, No. 18, Royal Institute of International Affairs, London.

[7] For table showing German production and net imports of basic minerals see Bureau of Mines, "Mineral Production and Trade of Germany, Italy, and Japan," *Foreign Minerals Quarterly*, Vol. I, No. 2, April 1938, p. 6.

[8] *Raw Materials and Colonies*, Information Department Papers, No. 18, Royal Institute of International Affairs, London.

[9] Bisson, T. A. and others, "The United States at War," *Foreign Policy Reports*, Vol. XVII, No. 20, Jan. 1, 1942, p. 257.

it to say that we are now having a splendid example of the importance of the climatic factor in war in the case of India. Nicholas J. Spykman in his recent book, *America's Strategy in World Politics*,[10] asserts that if Germany driving from the west can meet, in India, Japan driving from the east, this war will be prolonged by many years. I think it is too late for this to happen during the current summer for the summer monsoon has now burst. The gathering masses of watery vapor driven without check over the surfaces of the heated Arabian Sea and Bay of Bengal literally "let go" when they strike the Western Ghats Mountains, the Khasi Hills and the Southern Himalayas. Thus Cherrapunji, 200 miles north of the Bay of Bengal in the Khasi Hills, is the rainiest place in the world with an annual rainfall *averaging* 426 inches.[11] The rain descends in liquid sheets for hours at a time. In 1861, 905 inches fell—366 inches in July alone, and 41 inches in 24 hours. While such rain does not characterize the entire country, most of India receives heavy precipitation in summer. It is obvious that mechanized troops could make only slight headway in a country poorly provided with roads and drenched with rain, where rivers overflow their banks and jungles resemble what we encounter when we enter a greenhouse. Did you not note Japan's frantic effort to clean up the campaign in Burma before the coming of the summer monsoon and have you not noted a recent slowing down of Japanese activity in southeastern Asia? Unless Japan wishes to consolidate her gains, or unless the United Nations are much stronger in India than they have been up to the present, operations should be possible again on the Assam-Burma frontier in the autumn.

The Russian Winter.—Some say Russia appears to have been blessed by Providence in repelling advances of invaders. It is well known what happened to Napoleon and his men in their invasion. The French forces were fortunate if one in ten men got out alive. Charles XII, of Sweden, failed also against the forces of Peter the Great. When Hitler invaded Russia on June 22, 1941, he planned a lightning war on the model of Poland and France; many military observers thought Russia would do well to last 6 weeks.[12] No provision was made for a winter campaign. After four months of fighting without having accomplished their aim, the High Command decided to make another attempt to take Moscow—this time for winter quarters and protection for the soldiers against ice and snow. Not only did the Russians successfully resist the Germans, but in some sectors they took the offensive and Germany paid a tremendous price in men and materials. As a scientist, I cannot tell what part Providence has had in this, but I do know geography in the form of *winter weather* has played a vital rôle.

How cold does it get? That, of course, depends upon the place in mind, for Russia is huge. The average January temperature at Leningrad is 18.3°, the minimum −39°; the average January temperature at Moscow is 12.6°, the mini-

[10] Spykman, Nicholas J., *America's Strategy in World Politics*, Harcourt, Brace and Co., New York, N. Y., 1942.

[11] Kendrew, W. G., *The Climates of The Continents*, Oxford University Press, New York, N. Y., 1942, pp. 130–131.

[12] *Foreign Policy Bulletin*, December 19, 1941, p. 1.

mum −43°; the average January temperature at Archangel is 8.1° and the minimum −49°. All temperatures are given on the Fahrenheit scale.

Frosts begin in European Russia about October 1st, and the ground is stone-hard by November 15. Winds of near hurricane force are weekly affairs. Ukraine farmers expect frost as late as May 24. With such temperatures the "conduct of war is definitely dictated by winter." General H. S. Sewell, one of Britain's leading commentators on military history and strategy, said on December 17, 1941, "The generals know full well (if Hitler does not) how near the limit of endurance the bitter fighting and the cold of Russia . . . brought the Nazi soldier."

MURMANSK AND ARCHANGEL

Two of the war's most important treasures in the Union of Socialistic Soviet Republics are petroleum and manganese. Manganese hardens the steel of war[13] and oil runs the engines of war. "In the final reckoning, all modern war comes down to fuel." If the Germans fail to take Stalingrad on the Volga River and the oil of Baku, their Russian victories will be "sterile for want of fuel replenishment." Oil is the Achilles heel of the German war machine. If Hitler could acquire the oil of Russia, Iraq and Iran, his petroleum problem would be solved and he would have a strategic stronghold on the very heart of the War. The best defense of the United Nations, therefore, is to get all the war supplies possible into Russia. These at present[14] move over two routes (1) around the Cape of Good Hope to the Persian Gulf (a sea voyage of 11,000 miles from Britain, or 12,000 from New York) and (2) over the northern route to Murmansk and Archangel (5,400 miles from New York and 2,400 miles from Britain). Note that these cities lie north of the Arctic Circle, and far from the theatre of the war.[15] Murmansk, despite its location in latitude 68½°N, is kept open the year round because of the warm Gulf Stream Drift. It is to prevent convoys from reaching Murmansk that German battleships, U-boats, dive bombers and torpedo planes infest the coast off northern Norway.

Shipments to Archangel are less satisfactory because ice completely halts traffic to the White Sea for at least five months out of each year. In 1915 three Canadian icebreakers kept traffic moving through November and December but they failed in January, 1916. Not until the end of June did 30 Allied merchant ships break out of the implacable grip of the ice.

RUSSIA, GERMANY, JAPAN AND GEOPOLITICS

Russia is a huge country, including one-seventh of the world's land area or three times that of the United States. Russia is also rich. The most advanced

[13] Manganese is absolutely necessary in making steel, both for hardening and for purifying the metal. The only countries ranking high in manganese production are Soviet Russia, India, the Gold Coast, and Brazil.

[14] Editor's note: True when this address was given. With the establishment of a second front in North Africa, as this goes to press, the much shorter Mediterranean route may eliminate the two discussed here.

[15] The Finns have cut the main rail route connecting Murmansk and Leningrad, though a branch connects this road with the Archangel-Moscow line.

parts industrially were along the south and southwest portions—especially the Donets Basin. Had not the Russians anticipated the present death struggle, the country might be prostrate today with its great industrial area, the Donets Basin, in German hands. Russia was transformed, following the Revolution, from a backward and mainly agricultural country into a well-balanced agro-industrial state. The industrial development has been proportionately greatest in the East—the Urals, Siberia, and Kazakstan—areas rich in coal, iron, copper, and other minerals. These industries now are supplying Russia with most of the weapons of total war.

Why does Germany want Russia? Because the gigantic citadel reaching from the Elbe to the Amur and from the Himalayas to the Arctic Ocean forms the "heart land", the great pivot area of the earth. It contains all the advantages indispensable for a Germany at war against any great power or combination of powers. It is the deep base from which Germany's military forces might strike in all directions while her vital war industries could be withdrawn to remote inner regions. With the riches of the Ukraine, the Caucasus, the Urals, and interior Asia, Germany would be the nearest approach to economic self-sufficiency in the entire world. Thus Russia would be a rich prize to the Nazis[16]—especially its oil, the total output of which was estimated at 220 million barrels in 1940. Of this amount 75 per cent comes from the fields around Baku on the Caspian Sea. The Germans need this oil badly. In the summer of 1942 it is estimated that the Germans are using in excess of 60 divisions (one million men) in the attack on Stalingrad. An army of this size would require more than 100 tons of gasoline alone for every mile that it moves. If Germany could win in Russia and if Germany and Japan could meet, which seems unlikely to me, many strategists assert the Allied Nations could not possibly assault this great land mass, for they could not get together the necessary ship tonnage. Moreover, Karl Haushofer, father of modern German geopolitics, believes the day of sea power is over, that it is no longer the decisive element in a struggle between the Great Powers. He contends that Eurasia is a land of destiny and that who controls it can defeat those who merely control the oceans and seas. Haushofer adopted this theory as a line for Germany's drive for world power in terms of *Lebensraum*.[17]

SUMMARY

Yes, ours is an interdependent world. Nature, in giving us many climates, diverse land forms, variegated soils and vegetation, and an unequal distribution of minerals, aggravated and facilitated the causes of war.

[16] Because of Russia's great size and the inadequate transportation facilities over much of it, prospecting had not been carried on in the greater part of the country. In recent years, however, several hundred geological parties have spent each summer in the field and many new sources of mineral supply have been found. Today Russia ranks alongside the United States in its riches of natural resources. See Bureau of Mines, *Foreign Minerals Quarterly*, "Mineral Production and Trade of Russia," Washington, June, 1938.

[17] Most American geographers look upon the German brand of geopolitics as wholly unscientific speculation. For an excellent treatment of this subject see Strausz-Hupé, Robert, *Geopolitics: The Struggle for Space and Power*, New York, 1942.

We in America, partly as a result of our ignorance of geography, must realize that we are involved in a global war, not merely in a struggle for the domination of any single continent. "This war is a world-wide struggle for control of strategic bases, sea lanes, and the raw materials necessary for militarized industry."[18] We must realize, too, that there are no separate theaters of operations, that the whole war is one and the entire globe—earth, sea, and sky—is its battlefield. We must see the war as the Axis sees it, as a global war, as total war, in its geographical, political, economic, and psychological aspects rather than in military terms alone. We must employ all the tools of war in successive campaigns planned and carried out in accordance with a sound geopolitical blueprint. To do this we must have a clear and realistic picture of the world in which we are fighting. Let us no longer take the geographic factor of world politics for granted.[19]

Finally, humanity's big job, it seems to me, once this war is concluded, is to see to it that some plan toward a permanent peace is worked out. A world war every generation is intolerable. Perhaps a federal government of nations could make raw materials and markets over the world available to all who need them just as we handle the situation within the United States. The great South American liberator, Simon Bolivar, dreamed of "cooperation without conquest and peace without empire"; perhaps this is the answer. But whatever happens, we must know our world better.

[18] Bisson, T. A., and others, *Op. cit.*, p. 246.
[19] *Ibid.*

THE MEANING OF SCIENCE IN HUMAN AFFAIRS[1]

C. JUDSON HERRICK[2]

Received October 27, 1942; published February 2, 1943

"The meaning, or intrinsic value, of life is the center of human interest." This is the introductory sentence of a paper read by the late George E. Coghill before the Denison Scientific Association on November 23, 1909. The idea here expressed was not amplified. He was speaking about "Science and Optimism," and the lapse of thirty-three years may have wrought great changes in our outlook upon this theme. What has science contributed to the intrinsic values of life, and what has science to offer in this domain for the future? In short, what is the meaning of science in terms of human values?

First, we must recognize that the science of 1942 is not a body of absolute knowledge, fixed and unchangeable. Natural science as of today may be defined as the codification and interpretation of the sum-total of human experience. It cannot go beyond that experience and inferences drawn by faultless logic from that experience as premise. It knows no absolutes; it is unfinished and fallible. The meanings of science are human constructions, and their significance and worth are realized only in terms of human satisfactions.

This is my scientific creed, but it is not the conventional idea, which regards science as a system of abstractions remote from all human interests and values. It is my purpose to point out that this widely accepted code is defective, disastrously so if science is to live up to its opportunities and obligations and perform its proper function in the resolution of those acute problems of human adjustment with which we are now confronted.

[1] Read on October 27, 1942, before the Denison Scientific Association under the auspices of the Denison University Research Foundation.

[2] Dr. C. Judson Herrick, a charter member of the Denison Scientific Association in 1887, was elected to the first honorary membership of the newly formed Denison University Research Foundation. On the occasion of his visit to Granville for his initiation he delivered an address before the Denison Scientific Association.

The recognition by the Foundation, which has been formed to encourage undergraduate research, is especially fitting because C. Judson Herrick was an undergraduate at Denison in the spring of 1887, when the Associotion was founded by his older brother, the late Clarence Luther Herrick.

C. Judson Herrick's earliest researches on the nervous system of fish were carried on while he was professor of zoology at Denison, and won for him national recognition when the New York College of Physicians and Surgeons awarded him the Cartwright Prize in 1904.

Closely identified with Denison University as preparatory student, undergraduate student, graduate student and teaching fellow, then instructor, and finally professor and head of the department of zoology, C. Judson Herrick was associated with this school for more than 20 years. He holds both master of science and doctor of science degrees from it. He left Denison in 1907 to become professor of neurology at the University of Chicago, a post held until his retirement as professor emeritus in 1934. (Denison News Bureau.)

Natural science is a search for the meanings of things. In our traditional code of the methods and objectives of science these meanings are detached from the particulars which are experienced during the course of the investigation, they are generalized in abstract terms, and these generalizations are woven together into a coherent system of knowledge which we call the Order of Nature. This is the correct procedure as far as it goes and it has yielded an imposing body of knowledge and the triumphs of current scientific technology. But it stops short of our true objective, which is human welfare, not merely in terms of inventions which make life more comfortable and enlarge our spending power, but in terms of those satisfactions which arise from improved capacity for production and enjoyment in the realms of those higher values upon which a stable and efficient civilization depends—to wit: opportunity for every individual to develop his native abilities to the limit of his capacity and encouragement to do so; strengthening the fiber of the racial stock in conformity with the known principles of eugenics, personal and public hygiene and medical science; social cohesion and comity, with substitution of cooperation for factional strife; international harmony brought about through subordination of nationalistic ambitions to reciprocal adjustments in the interest of peace and universal welfare. These urgent problems can be solved by the application of the scientific method and in no other way, and this method as here applied cannot operate with abstractions divorced from the interests and attitudes of the people concerned. Science cannot perform this, its most important function, unless the values desired are clearly set forth, judiciously chosen, purposefully sought, and the methods adjusted in conformity with the human capacities and interests involved.

The scientific principles which formulate our present ideas of the meanings of things were generated by men and women confronted with personal problems, these problems were solved by personal effort in ways determined by the personal qualifications of the observers, the product achieved is always affected by this "personal equation," and its scientific value is measured, in the long view, by its social effect upon the people who compose society.

Science has given us gadgets which have added greatly to the comfort and productivity of life, but these are not the values that count most for ensuring deep satisfaction and that social stability upon which our future happiness depends. The most unhappy people I have ever known were endowed with inherited wealth, which they never learned how to use. Their yachts and other gadgets could not satisfactorily solve their only acute problem—how to kill the next half day with least ennui. One of them actually committeed suicide for lack of anything better to do. Gadgets do not enrich the intrinsic values of life.

Is this all that science has to offer? It is currently believed that this is so and that the scientific optimism of a generation ago must now give way to discouragement and despair. An editorial in the *London Times* (Jan. 24, 1927) solemnly announced, "The arcana of power are no sooner mastered than they are harnessed to the most prosaic needs. . . . Very useful, of course, the sceptic will say, are many of the latest dodges for doing necessary but undistinguished

things; but how dull! Science has not found out everything, but there is a strong inkling that the thrills and raptures of scientific adventure are over. No future Newton or Darwin is expected whose discoveries will seriously affect the framework of men's thought on things that really matter." "Now that nearly everything is known," he says, "nothing new will astonish" and science can be put in its proper subordinate position, for "the universe turns out to be a less exciting place than it once promised to be."

One wonders in what ivory tower this cultured man has lived since the dawn of this century. Have our Einsteins, Rutherfords, Walter Reeds and Harvey Cushings lived in vain—for Britain? They have not for the rest of the world. The universe turns out to be a far more exciting place than it used to be because men of science have plumbed its depths, and the thrills to be got out of living in this universe are keener and richer because life's intrinsic values are enlarged and refined just in proportion as we learn how to live harmoniously in this world of natural law and order.

Our conquest of nature has perhaps gone, not too far, but too fast; that is, faster than the conquerer has been able to subdue his own spirit. The danger is that the robot may become the master of its inventor. The remedy is, not more raw passion or crass sentimentality, but more intelligent use of our brains and more efficient control of ourselves.

Our intrinsic values are personal possessions. They are not gadgets that can be traded in the open market. They are what we individually make them to be and they are not transferable. They are not absolutes of perfection of some inaccessible transcendental realm. They are products of our own ways of life, for better or for worse, and they motivate our conduct, for better or for worse. Now, all vital processes are legitimate objects of scientific inquiry, and science, so far from being indifferent to these intrinsic values which we have made, offers our best technique for the appraisal of their true worth and of the appropriate ways to express them for the enrichment of life and its higher satisfactions.

This, I know, is not the tradition of our cult and there is some justification for the peevish disparagement of scientific achievement of the *Times'* editorial. It is high time for science to take an account of stock. Just what values are we working for, and is the traditional code of scientific methodology adequate for our present needs and opportunities? This is a personal problem with each of us and so I shall speak for myself in the first person. It may be profitable to examine the scientific method and output from the standpoint of the people who try to live the life of science and who actually do the work.

Let us substitute for the announced title of this address a less formal theme—THROUGH THE LOOKING GLASS, OF A NATURALIST LOOKS HIMSELF IN THE FACE. Let us invoke the magic of Lewis Carroll and try to see through the looking glass into the wonderland behind it. You remember when little Alice looked in her mirror she saw first her own image and then through it and behind it a wonderland of imagination and phantasy. It all puzzled her childish mind.

"Somehow," she said, "it all seems to fill my head with ideas—only I don't know exactly what they are."

As I look into my shaving mirror every day I see a face, not lit up by charming whimsies like Alice's sprightly and elfin countenance, but rather thoughtful and perhaps a bit frowzy. Anybody looking over my shoulder can see the same face, but the reflected image is an incomplete picture; it cannot satisfy Bobby Burns' demand:

> O, wad some Power the giftie gie us
> To see oursils as ithers see us.

Nor can it give me any but superficial knowledge of myself, for back of that face is a person who leads a double life, part of which is open to public inspection and another part is known to himself alone. Yet it is only one life that he lives, not two, and this is what makes it a wonderland.

Now, science is supposed to belong in the public world, detached, impersonal, and the whole theory of the objectives and methods of science has been built up around that supposition. But in practice it does not work out that way. A cursory glance at the history of science shows that at the focal point of every scientific achievement there is a person, and the announced discovery, whether ultimately it proves to be right or wrong, carries the impress of that person's inner nature. The essential quality of science can no more be detached from the characteristics of the people who generate it than my own overt behavior can be separated from the hidden inner springs of motivation that activate it.

These inner motives that shape the course of conduct are not entirely concealed from observation and it is the business of science to discover them and find out how they work. Some of them, like tropism and reflex, are frankly physiological and others, like ambition, hope and aspiration, are accessible by various psychological procedures.

Scientific investigation is variously motivated and its product is shaped in part by this motivation. The course of a research program is internally determined, in fundamentals, and for a proper understanding of it we must know the people who make it and use it. Science itself is not something in the world outside of us that we try to discover; it is something that we ourselves have made and it remains with us as a human heritage. The humanistic components of science cannot be eliminated and they must not be ignored. The personal equation is always there; sometimes, as in astronomical observation, it can be measured; and always it must be taken into account in the interpretation and evaluation of any scientific process or product. Having made our science what it is today, let us try to appraise its true worth.

Little Alice through the looking glass saw a topsy-turvy world. We do not need mirrors or spectacles to see that our present world is topsy-turvy, and some people charge this disaster up to natural science, with its crudely mechanical outlook and neglect of human values. A strong brief may be written for this

indictment, I think, if we complacently accept the prevalent view of the detachment of science from all human interests, motives and satisfactions. But the whole history of science cries out against this arbitrary restriction of our freedom to employ all of the resources of our human nature to investigate this same human nature. No less authority than Bertrand Russell, who should know better, has fallen into this trap when he says,

> "The sphere of values lies outside science," and when science "takes out of life the moments to which life owes its value, science will not deserve admiration, however cleverly and however elaborately it may lead men along the road to despair. The lover of nature has been baffled, the tyrant over nature has been rewarded. . . . Thus science has more and more substituted power-knowledge for love-knowledge, and as this substitution becomes completed science tends more and more to become sadistic. . . . The scientific society in its pure form, which is what we have been trying to depict, is incompatible with the pursuit of truth, with love, with art, with spontaneous delight, with every social ideal that men have hitherto cherished, with the sole exception of ascetic renunciation."

This loathsome picture of the outlook of a science devoid of values follows logically from the premise; it is the legitimate conclusion to be drawn from the traditional code as expressed by the formula, "science knows no values," or by Ogden and Richards when they say, "Scientific meaning is a pure pointing to things without attitude or indication of behavior." But scientific method is bound by no such fetters and with the removal of these shackles "the major human issues" are opened up as legitimate fields of scientific inquiry.

If we explore our values from the biological point of view and with biological technique, we shall find that values must not be disowned by science, that the naïve curiosity, the thirst for knowledge, the ideals, ambitions, satisfactions, honors, emoluments—even the pay check—which motivate research are neither adulterants nor by-products of pure science but integral parts of it.

This theme cannot be elaborated now. I maintain that it is possible to write a natural history of value and to show that there has been an evolution here, from the primordial survival values common to all living things up to the most refined ethical values that mankind has achieved. These values inhere in the very nature of the vital process.

All animal behavior has been characterized by Dr. Harvey A. Carr as an expression of the satisfaction of the motivating conditions. Now, satisfaction is a value, and a value in just the same sense (though with very different connotation) whether it is achieved physiologically, as in tropism, or psychologically, as in artistic composition and moral aspiration.

This conception of value as related with needs and satisfactions is defended and amplified by competent authorities—Perry, Alexander, Bouglé, Sellars, Morris, Dewey, and many others. Professor Santayana says, "Satisfaction is the touchstone of value," and some kind of satisfaction of organic needs is attained in every normal vital process. Our most refined values would never be realized if we did not need and crave them, for, as Bouglé says, "True values are the things men set their hearts upon."

Scientific investigation is a vital activity; it is something we do with our

bodies. Satisfactions are achieved as we go on with it; otherwise it would not be done. These satisfactions, the values sought and won, are inherent in the research process; they are not something adventitious and therefore negligible.

Let us leave our values where we find them—in the natural world—and then let us find out as much about them as we can in the hope of enlarging and refining them. This may leave philosophy bereft of some of its cherished idols, but the practical problems of human adjustment are rendered more accessible, and there is plenty for philosophy to do in this field. For successful living we must learn to evaluate our values, to appraise them in terms of types of satisfaction desired, and to select wisely the ends toward which our efforts are directed. This appraisal of the real worth of things is a crucial matter and no better technique for it has yet been devised than the tried and tested methods of science. But science cannot find the answers to the questions that most concern us—how to get along with ourselves and with one another—by ever so clever an application of a scientific method which excludes the essential factors of the problem from its formulation. A science which knows no values is powerless to deal with the biggest scientific problems of our time.

But science is not defeated here; it is competent in the field of human interest and action if only we are willing to try it radically and fearlessly. Defeatism has no place in our program.

As I see it, the essential business of science is not fact-finding; any competent person can do that. The crucial matters are, What do the facts mean? and What shall we do about it? A fact—if true—is itself of some value, and the specific tasks of science are two: first, the orderly arrangement of facts into a coherent system of knowledge; and, second, the evaluation of these facts in their relations to human interest and welfare. The first of these is everywhere recognized as the function of pure science, and the ideal held before us here is an impersonal and unprejudiced judgment in the separation of the true from the false, the accumulation of verifiable facts stated so far as possible in quantitative terms, and their systematic arrangement in orderly categories. From the uniformities thus revealed the so-called laws of nature are formulated.

Now the evaluation of this knowledge and its applications in human affairs are traditionally regarded as no legitimate business of pure science and these are set apart in a special domain of applied science. But when the attempt is made to define the boundaries of these domains we find ourselves in a hopeless muddle. The systematizing of knowledge implies classification of facts, and any classification is necessarily an evaluation. The systematist formulates classes or categories, selects from the total body of known facts those which fit into the scheme adopted, and then ranks them accordingly. The selection is made by the investigator, and its utility or practical value for his purpose is appraised in terms of its fidelity to the natural relationships of the data selected. Science is thus infiltrated by human estimates of value at every step of its progress.

A glance at the question from the other side, that of applied science, reveals

a similar interrelationship between the applications of science in the interest of human welfare and the general laws of nature discovered by pure science. The values attained by applied science are the fruition of pure science. It is now quite generally agreed that the distinction between pure and applied science has faded out of the picture. But it is not so generally recognized that this implies that values are intrinsic in all science as such.

Our trusted leaders in both science and philosophy are becoming more and more emphatic in driving home this basic truth. Let us quote a few examples.

"In the end I believe we have come to see that the scientific method is characterized in considerable measure by attitude of mind and desire for truth rather than by complete mathematical-physical solutions of questions."—John C. Merriam.

"In its practical aspects the ethics of science includes everything that concerns human welfare and social relations."—E. G. Conklin.

"Science is a cooperative effort toward a united understanding, it is an eternal future, an everlasting hope."—Edwin B. Wilson.

"And when we add that logical habits, sanctioned by utility, are needed to interpret the data of sense, the humanity of science and all its constructions become clearer than day. Superstition itself could not be more human."—George Santayana.

"It is because of injection of an irrelevant philosophy into interpretation of the conclusions of science that the latter are thought to eliminate qualities and values from nature. Thus is created the standing problem of modern philosophy—the relation of science to the things we prize and love and which have authority in the direction of conduct."—John Dewey.

Very recently, in his book on "Freedom and Culture," Professor Dewey writes, "Science through its physical technological consequences is now determining the relations which human beings, severally and in groups, sustain to one another. If it is incapable of developing moral techniques which will also determine these relations, the split in modern culture goes so deep that not only democracy but all civilized values are doomed."

In another place in the same book Professor Dewey points out that "the future of democracy is allied with the spread of the scientific attitude." The patterns of social, industrial and political organization are fluid, and the direction of the flow is in part determined by the mental attitudes and operations of the individuals. To see that these movements are properly directed is the task of education. "Until what shall be taught and how it is taught is settled upon the basis of formation of the scentific attitude, the so-called educational work of schools is a dangerous hit-or-miss affair as far as democracy is concerned." And this can be done, for "science is capable of developing a distinctive type of disposition and purpose." The dismaying proof of this we see in some of the totalitarian dictatorships at the present moment. We in a democracy can do a better job of it with our own type of educational system if we try.

It is a cardinal principle of scientific method that judgments of fact and ensuing courses of action be determined in the light of verifiable experience critically evaluated rather than by tradition, prejudice, blind acceptance of

authority, or irrational primitive emotion. Most of the tragedies of life, both in our personal affairs and in our social relations, result from failure to observe this simple rule of common sense. International disorder and our present acute peril have resulted from just this failure. Narrow-minded nationalism, lust for power, ruthless personal ambition and sordid greed are incompatible with that stable social order without which civilization cannot survive. These things do not make sense in our time, and yet we have tolerated them and continue to do so in many quarters—some not so far from home—in the face of the obvious lessons of all human experience.

Past failures to profit by this experience are due in some measure to misdirected effort. The accepted code of impersonal scientific procedure can deal with statistics, but not with motives. It can tell us what people buy with their money after they have spent it, but not why they spend it as they do. The control of expenditures by taxation and other forms of regimentation may at times be necessary, but it does not strike to the root of the problem. When we succeed in controlling motivation judiciously no such inept regimentation is necessary.

This is the prime task of education, admittedly a difficult program. The necessary factual knowledge is hard to come by and the interpretation of the facts requires rare discrimination and judgment. It is much easier to postulate some general principles and from these deduce the proper procedure. This is the method of normative science as distinguished from natural science. The normative method has the further tactical advantage that the principles, or "universals," postulated may be so chosen in advance as to deliver by valid logical argument the conclusion desired. Normative science is very useful in its place, but it is not the way out of our present disorder.

In the normative disciplines like logic and mathematics the postulated norms and standards of procedure, having been laid down by definition, predetermine the scope and method of the inquiry. The natural sciences, on the other hand, are based on fluid experience. Their norms, or "laws of nature," are not postulated at the beginning of the inquiry, but they come (if at all) at the end of it. Natural science, accordingly, has no absolute standards, for these are universals and human experience is limited and relative.

The relations of these types of procedure to practical problems of methodology were brought to sharp focus in my mind by the remarks of an eminent philosopher at a conference a few years ago. The distinction was drawn between norms (which are universals) and natural objects and events, which we shall here call for short "things." These things exist in the sense that they have locus in space and time. Norms, he said, do not exist in this sense. Normative science, then, does not deal with existences. He distinguished between the natural (empirical) sciences which deal with existing things and the normative sciences (typified by mathematics and logic) which deal only with postulated norms that have no existence. An "applied science" which deals only with things is not a true science. All "pure science" is essentially normative. It takes its departure from certain norms (universals) assumed as working hypotheses and then

proceeds to test their supposed universality empirically, either in terms of consistency with normative canons of procedure (logic, mathematics) or in terms of consistent (repetitive, verifiable) experiences of things (natural science).

Pure science is here set apart in an ivory tower of its own where the investigator is effectually insulated from the "things" in which he is interested. However satisfying this analysis may be to the philosopher, it leaves the naturalist confused. As he surveys the history of natural science he sees that the chief obstacles to progress have been—and still are—the dominance of some traditional dogmas which are uncritically accepted as universals. These unverified dogmas, which it is alleged are not "things" of experience, nevertheless seem to have very real existence, so real in fact as to close and bolt many doors of promising inquiry for centuries. Not until these really existing obstacles to inquiry are removed can science advance into new fields.

The distinctive characteristic of natural science is not its norms, but its method of using experience. The naturalist uses mathematics, logic and other normative disciplines as tools of research, but these are not his science as he envisages it. Of course, one may define science in any way that he likes—to embrace Christian Science, or boxing, or commercial assaying or calculus—but natural science deals with nature, that is, with "things," by definition. The naturalist's attitude toward these "things" is the same as that of good common sense. They are compared, classified, measured, standardized and interpreted; but science is more rigorous in its method, demanding verification, precision and consistency of higher order.

Our interest here is in the natural sciences as thus defined. The confusion of natural science with normative science has had disastrous consequences throughout the history of human thinking; and nowhere are these disasters more pernicious than in the current theory and practice of education.

A glance at the history of education shows, among others, three prevalent methods of going about it. These we may call trial and error, normative and scientific.

1. Rule of thumb methods of teaching, slowly elaborated by trial and error, are the oldest and even yet perhaps the best we have. Experience painfully and wastefully acquired by blind fumbling has justified some procedures by their results and thrown others into the discard.

2. Normative methods aim to improve upon the slow and wasteful rule of thumb by search for the guiding principles, general laws or norms of pedagogy with which good practice must conform. This search for pedagogic laws, or normative rules of teaching, and the technique of their application in practice has prevailed in our teachers' colleges for more than two generations. That is why we call them normal schools. If we can discover the general principles of teaching of *universal* application, then pedagogy can be reduced to rule and teachers can be trained very simply to learn these rules and apply them. Theory guides practice. Everything can be standardized with great economy of money and effort and the "efficiency" of the system is correspondingly increased.

3. The third method of education I venture with some trepidation to call the

scientific. Teaching, of course, is an art, not a science, yet there is (or may be) a science of pedagogy. The scientific method may yield generalizations or laws of pedagogy which, to be sure, are normative principles, yet the use made of these principles in a scientifically directed program is radically different from that of the strictly normative disciplines.

The normative method takes its departure from the rule or law and aims to apply it. Theory dominates practice. Any system of theory which may be adopted by the administration can be imposed upon the school organization by regimentation. This regimentation may be applied mechanically by chuckle-headed drill masters whose indolence and arrogance reduce the school to a dreary grind of profitless routine. Or it may be administered vigorously and skillfully in the interest of some social, religious or political system of dogma.

A scientific pedagogy is the antithesis of this. It must be a combination of the other two methods mentioned, with the emphasis on experience, not theory. Practice is not subordinated to theory, but the theory emerges from the practice. This contrast is very sharp and its recognition is of vital importance. In the rule of thumb practice which has come down to us from antiquity theory is neglected. In the normative period of our time theory tends to regulate practice. This is as it should be; but in this case it is evident that our theories or norms must be critically examined as to their meanings, their origins, their applications, their practical results and the objectives sought. Otherwise the gravest abuses may follow.

From all this it follows that the naturalist gets no comfort at all from the normative absolutes which are so precious to the philosophers. They are of no use to him; indeed too often they are very much in his way, obstacles to be overcome, like the traditional dogmas and taboos of the folklore of mythology. As actually applied in educational practice they may be very dangerous, as already mentioned and illustrated by the prostitution of an efficient state controlled educational system in the interest of political propaganda as now seen in some totalitarian states.

The actual practice of the scientific method in education is so expensive, laborious and time-consuming that many educators seem to have no patience with it. Even so efficient and successful an administrator as my respected chief, the president of the University of Chicago, has, I fear, been led astray, like Sir Hudibras' squire, by some "dark-lantern of the spirit,"

> An ignis fatuus, that bewitches
> And leads men into pools and ditches.

Since he has invited discussion of his philosophy of education by many public announcements of it, I have the temerity to challenge some of the articles of faith of his educational credo. Among these articles we find the statement, "Questions of value are the important questions, and on these science sheds no light." And he adds, "In this matter of the ends of human life and human society science leaves us helpless; 'what ought we to do?' is not a scientific question." Here every man of science rises up in protest. In justification of

the supremacy of philosophy over science we read further that the type of activity of "scientists as such . . . will not suffice as the unifying agent of the social world. It is in this realm the agent of disintegration. To leave the field to it is to guarantee the ultimate destruction of society." To this the man of science replies that the contrast here drawn between philosophy and science is an artificial and pernicious dialectic. The mutilated and distorted picture of the methods and aims of science which is drawn in this context is a caricature which no competent naturalist would recognize. Indeed, he would say that search for the unifying agents of the social world is the biggest scientific problem of our time, and the surest way to guarantee the ultimate destruction of society is to discard the scientific method here.

In this connection Professor Mortimer Adler claims that scientists may explain the world in a descriptive sense but they cannot understand it. Confronted with such a statement, is it surprising that some men of science are contemptuous of this brand of philosophy? Even a philosopher may rebel, as when Bertrand Russell says, "To the completely unintellectual, general doctrines are unimportant; to the man of science they are hypotheses to be tested by experiment; while to the philosopher they are mental habits which must be justified somehow if he is to find life endurable." Professor Dewey makes the more temperate statement, "Scientific method in operating with working hypotheses instead of with fixed and final Truth is not forced to have an Inner Council to declare just what is Truth nor to develop a system of exegesis which rivals the ancient theological way of explaining away apparent inconsistencies." Justice Holmes is said to have remarked, "The great act of faith is when a man decides that he is not God. . . . Philosophy seems to me, generally speaking, to sin through arrogance."

The naturalist sitting on the sidelines may watch these contests of the dialecticians as a sporting game and cheer the home team if he likes, or in complete detachment he may turn to his preoccupation with "things" and rest assured that no scientific interests are jeopardized thereby. But he cannot retain his complacency if the certitudes of philosophical authority invade his own field and contaminate his method. What neither common sense nor science has granted is promised by philosophy, with its universals, its eternal verities and norms of perfection. This seems to be an easy way out of our difficulties. Let philosophy tell us what is true, what is right, then all we have to do is to learn how to adjust to it. "The truth is everywhere the same; hence education should be everywhere the same" would be a comforting slogan if it were not for the disquieting question, What is this eternal truth and where shall we find it?

Philosophers for milleniums past have devoted themselves to a search for standards of perfection which are universal, absolute and eternal. This gives them something to tie to which is more firmly grounded than the imperfect and unstable generalizations of common experience, even when reinforced by all the refinements of natural science. As a naturalist I am interested in the sources and credentials of these norms of truth. It may be that they have a natural history of their own that is worth looking into.

Our interest here is in the premises, the postulates, the transcendental categories and the definitions upon which the norms of these philosophers are based. Who is to be the judge of their truth? Certainly the philosophers themselves have reached no consensus to which we may appeal. Each one of them selects his postulates to suit his own purpose, just as the mathematician does. It follows that all their universal principles, their absolutes or norms, belong in the domain of what Stefansson calls "knowledge-by-definition." This knowledge is absolute if you grant the definitions, but it is not final because of that "if" and all that it implies.

Horace M. Kallen says that we may and do believe in some things in spite of life and experience because belief in them, involving no action, involves no practical risk. So far as any discipline "has declared values to be operative without making them actually existent it has been only a black art, a magic. It has ignored the actual causes in the nature and history of things, and has substituted for them nonexistent desirable causes." Mere wishful thinking which does not touch life or its practical problems comprises a large part of the popular philosophy. Mental infirmities of this sort are to be expected among the laity, but by this time professional philosophy should have grown up and passed this adolescent stage, and indeed this adult stage has now been reached by perhaps the majority of experts in this field.

Coming back now to President Hutchins' philosophical credo, it is his acceptance of the traditional but utterly false and now outworn definition of what natural science really is that leads him to characterize the naturalist as a pebble-picker and to strip science of its essential qualities leaving to it only the trash of meaningless factual knowledge. Here the philosopher filches from science that which leaves her poor indeed with no enrichment of philosophy. It does not help matters any to take away from the naturalist all components of his work that make it interesting to him and important for others and then chide him for incompetence to contribute anything of value in the resolution of problems of vital significance in human adjustment. The naturalist protests this rape of his values and demands recognition of the intrinsic worth of knowledge of nature, acquired the hard way by close and accurate investigation of actual experience with it. No arm-chair formulation of "the basic philosophical questions" can replace factual knowledge acquired by adequately controlled experience codified and evaluated by sound scientific method. And I repeat, no more efficient technique has yet been devised for this evaluation than the time-honored scientific method.

As a loyal supporter of President Hutchins' vigorous and courageous administration of the University of Chicago, I wish to call especial attention to the interesting fact that his system of philosophical verities and absolute standards of perfection seems to have little relation with his actual practice in the administration of a great university. He gives lip service to an educational policy which would reduce his scientific faculty to the level well characterized by Thomas Huxley as "hodmen of science," yet in practice these are the men whom he delights to honor. Three of the four higher divisions of the university organiza-

tion are explicitly scientific and the resources of the institution are devoted largely to the advancement of science. During its fifty years of life no president of this university has so staunchly and liberally supported its scientific activities as he has done and still does. It may be that Professor Kallen's remark already quoted is the correct diagnosis in this case.

This is the significance of natural science for human affairs as I see it. Neglect or disparagement of science is not the way out of our present disorder. What is needed is, not a moratorium of science, but a clearer understanding of what the scientific method is and realization of the fact that honest and intelligent application of this method is our only hope of relief from the turmoil that uncontrolled lust for power has generated in both our foreign and our domestic affairs. The values for which we work and fight must be appraised, not in terms of ape-and-tiger standards or political expediency, but in terms of what makes life worth living in modern civilization.

After more than fifty years of intense preoccupation with science, I ask myself, Why? The answer is simple: Because I like it. It gives me satisfaction. The Nobel prize winner Michelson put it this way, "because it is such corking good fun." This was, for him, a sufficient reason for devoting his life to the study of light and mirrors; but it is not a good enough reason to induce a group of hard-boiled business men to pay him a handsome salary for life for doing it. Somebody else might get fun out of using a mirror to throw a beam of sunlight into the eyes of motorists on a trunk highway, but these business men are not likely to pay him for doing it.

So it is obvious that two kinds of values are involved in all scientific investigation. One of these lies in the personal satisfactions of the investigator, what he gets out of it for himself; the other lies in the social consequences of his work. The second class of values is everywhere recognized; but the personal values have been disclaimed by science and regarded as an objectionable contamination of scientific method, with resulting misunderstanding and confusion of the issues. My purpose here is to defend science, not from its enemies, but from its purblind friends.

THE DENISON UNIVERSITY RESEARCH FOUNDATION[1]

The Denison University Research Foundation was incorporated in June, 1942, for the purpose of fostering and encouraging constructive research in the arts and sciences. The Foundation was started through an initial gift from an anonymous donor, and it is hoped that through the years additional gifts to the endowment fund will be made.

Officers and trustees of the Foundation are President Kenneth I. Brown of Denison University, chairman; Dr. Elizabeth C. Crosby, professor of anatomy in the University of Michigan Medical School, vice-chairman; Dr. Millard Brelsford, Granville, Ohio, secretary-treasurer; Dr. Elmer M. Jones, professor emeritus of chemistry at Adrian College; Mr. Frank B. Amos, Cambridge, Ohio, publisher; and Mr. Charles H. Spencer, Newark, Ohio, publisher.

The first honorary membership of the Foundation went to Dr. C. Judson Herrick, professor emeritus of neurology of the University of Chicago, and charter member of the Denison Scientific Association.

The first activity of the Foundation was to bring Dr. and Mrs. Herrick from their home in Grand Rapids, Michigan, for a visit to the Denison campus on October 26th and 27th, 1942. In the evening the Trustees gave a dinner in honor of Dr. and Mrs. Herrick, and following the dinner the fall meeting was held. Dr. Brelsford, the treasurer, announced an anonymous gift of $500 to be used during the current year for the purposes of the Foundation.

These purposes have been stated as fellowships and subsidies to worthy students and faculty members. It is hoped that early announcement can be made of such project or projects as may have been approved for the current academic year.

[1] From the President's Office, Denison University.

DENISON SCIENTIFIC ASSOCIATION

Organized April 16, 1887

REPORT OF THE PERMANENT SECRETARY FOR THE YEAR 1941–1942

Officers of the Association during the college year 1941–1942 were:
L. C. STECKLE, *President*
R. H. HOWE, *Vice-President*
C. S. ADES, *Recording Secretary and Treasurer*
W. C. EBAUGH, *Permanent Secretary and Editor*
L. E. SMITH, *Librarian*

With the completion of the new Life Science Building on the Denison campus, many meetings were scheduled for its commodious and splendidly equipped lecture room; where reasons for using the older rooms in other buildings existed, however, the Association acted accordingly.

October 14, 1941

TIT-TAT-TO TAKES A COLLEGE DEGREE. FORBES B. WILEY.

Many attempts have been made to define mathematics, none of which has been entirely satisfactory. "Mathematics is a game played according to the rules with meaningless marks on paper" is one of these interesting definitions. Comparing a game with mathematical thought, it was shown that the field, players, rules, the play itself, and the objective were analogous to operations dealing with points, transformations, patterns, the principle of duality, theory of higher dimensions and other mathematical concepts. With cleverly conceived color sets the analogies to tit-tat-to, checkers, dominoes and chess were demonstrated, and from these relatively simple games played on a two-dimensional (plane) surface new possibilities of games in three-dimensional coordinate fields were derived.

October 28, 1941

VISUAL EDUCATION. G. P. CAHOON (The Ohio State University).

It is recognized that there are variations in competencies among educational methods for achieving goals in view, and that visual education is only one of many means to a given end. It does lead away from the old "assignment-recitation" method of teaching and introduces a new spirit into instruction. Attention is substituted for indifference, with consequent gain in educational results; but by no means are visual aids to be considered as panaceas. One great disadvantage of this type of instruction is the impossibility of scheduling far in advance programs to fit into a given course, for the material needed may not be available just when wanted. Demonstrations were made of overhead pro-

jection, coated and uncoated slides, slides of ground glass, cellophane (cut on a typewriter with carbon paper, not with a ribbon), use of cells in projection apparatus, as for showing electrolyses, precipitation reactions etc., the manufacture of cells by using rubber bands (like those from Mason jars) between glass plates held together by rubber bands or friction tape, utilization of matter from books and magazines by mounting it on cardboard or paper with a rubber cement, and many other aids to visual instruction.

November 11, 1941

SOME NEW MEASURING INSTRUMENTS. W. C. EBAUGH.

"Brains in a Box" might well describe some of the marvelous instruments now available to scientist and technical worker, because in them are combined the factors of accurate measurement and intermittent or continuous regulation of conditions. For temperatures, pressures, weights, volumes, specific gravities, calories or British thermal units, speeds, barometric and hygrometric values, electrical conductivities, potentials and other quantities, etc., automatic indicators and recorders have been used for many years; but it is only within a comparatively recent period that instruments have been developed for determining the end points of analytical operations like neutralizations, oxidation-reduction reactions, cyanide titrations, etc. In these fields the use of electric devices to measure or control chemical reactions is finding wide applications. A late model of a Leeds and Northrup instrument for measuring pH (momentary acidity or hydrogen potential) values through a wide range, and a Fisher "Titrimeter" with electronic controls for determining end points in neutralizations, oxidation-reduction reactions, etc., were shown and used. The applications of such instruments in industry were then pointed out.

November 25, 1941

A closed meeting for members only was devoted to discussing the question "Can training along the lines of scientific method be transferred to other realms of thought and study, such as economics, sociology, philosophy, etc.?" As a basis for the discussion a report was submitted showing that tests with students of California Institute of Technology and Occidental College—both institutions in the Pasadena, California, district—showed zero correlation. The concensus of opinion indicated a belief that at least some of this kind of training could be and is transferred, but factors such as hereditary influences, methods of instruction, tendencies to memorize instead of to think, or to condense and be exact as with physical scientists and engineers in comparison with economists who are prone to be verbose and general, the short time a student is in college training to think and the long time it takes to effect permanent improvement in his ability to think—all these influences have their effects upon the individual student.

December 9, 1941

ARCHITECTURAL ACOUSTICS. C. S. ADES.

What are the distinguishing features of good and bad auditoriums? How does the use of acoustical material bring about a feeling of quiet in schools and

hospitals? Since sound travels 1120 feet per second in a room single and multiple echos are possible, and absorption materials, properly placed, are therefore employed to cause a rapid decay of the sound. Reverberations due to multiple echoes from all sides at once—a sort of "hanging in the air"—may be computed from the formula $T_0 = 0.05V/a$, where V = volume of the room and a = absorption factor. Illustrations of such computations were given, and the effects of acoustic plasters, celotex, rock wool in perforated metal, glass tile absorbents, and even the kind of an audience in the room were shown. By overdoing the job reverberation may be cut down too far, and the auditorium becomes lifeless and dull. The effects of shape, absorbing materials like carpets, rubber films and tiling, furniture, hangings, were shown in the cases of the Hill Auditorium (parabolic) at the University of Michigan and the Mormon Tabernacle (elliptical) at Salt Lake City. The measurement of sound in decibels, zero for barely audible sound up to 120 decibels for thunder and artillery fire, and the use of formulas to estimate reduction of decibels have had a marked effect in improving the efficiency of many types of structures such as schools, hospitals, offices, factories, churches and auditoriums.

January 13, 1942

THE EARTH'S MAGNETIC FIELD AND THE AURORA BOREALIS. L. E. SMITH.

The beautiful and unusually brilliant display of the aurora borealis ("Northern Lights") on September 18, 1941, directed attention to this spectacular phenomenon. Theories new and old to account for the electromagnetic disturbance, its influence upon radio transmission, relationships of solar conditions and the behavior of the upper layers of the earth's atmosphere, were presented; in spite of the immense amount of scientific work done, however, no adequate explanation of the aurora borealis has been forthcoming so far.

February 24, 1942

GEOLOGY OF THE SOUTH ATLANTIC COAST. F. J. WRIGHT.

The southeastern costal plain, from Cape Cod to Florida, is built up from debris of the Appalachians, and consists of a wedge of deposits between the old continental edge at its base and the present sea level; it is some 2200 feet deep, not consolidated, and includes everything from oldest cretaceous to present day clays and marls. The soil is not fertile but sandy, and by proper fertilization can be made good for crops such as peanuts, cotton and garden truck. The Chesapeake, Hudson and other bays and rivers represent drowned rivers or estuaries where the sea level has risen when the coast line fell. As all transportation in early days was along the rivers, the peninsulas between them became of historic importance. From the Chesapeake south one finds an emergent coast line, and Florida for 1000 miles is a protuberant coastal plane due to an elevation of an axis of coral and coquina rock. Cities have grown up along the "fall line" between Piedmont and the coastal plain proper. At the present time this part of our coast is important because of its defense against possible invasion. Both "stills" and "movies" in color were used to show the terrain described.

March 10, 1942

LIE DETECTION. BERNARD HIGLEY (Columbus Police Department).

The psychological foundations of the "lie detector" were explained, and their applications shown. The extent to which such evidence may be used in court, how far the court may go in accepting results so obtained, and the general and special applications of the instrument in legal, criminal and personnel problems were discussed. The actual use of the instrument itself was demonstrated. Patterns of delinquency appear at much earlier ages than formerly believed; too often symptom treating instead of fundamental cause studies for delinquents has been the rule. The teen-age does not begin to compare with the sixth or seventh year with maladjusted children in showing abnormal developments.

March 24, 1942

VITAMINS FOR PLANTS. JAMES MERRY.

Five classes of plant food requirements were listed as water, organic substances, the inorganic fertilizers like calcium, potassium, phosphorus and nitrogen, enzymes or catalysts, and vitamins. The last group has been studied chiefly in connection with animals, and is now having a large part in advertising. A claim made by a worker with plants that Vitamin B used on plants would cause a stimulation in growth was (unfortunately) exaggerated in the press; subsequent experiments disproved many of the claims, for it was shown that other factors than simply the Vitamin B complex were concerned. Nevertheless Vitamin B is necessary for roots of plants. Recent reports upon Vitamin B-1 Plus (where the "Plus" can include almost anything) are evidently based upon work where hormones are concerned too. And Vitamin C is important for fungi, as they are incapable of manufacturing their own food. So far, then, the verdict "Not proven" must be rendered with respect to the wonderful advantages claimed as resulting from the artificial addition of vitamins to ordinary plants.

April 14, 1942

TESTING STUDENTS AT DENISON UNIVERSITY. C. F. RICHARDS.

One of the most significant movements in American education during the past 15 years arises from the recognition of individual differences in students' abilities, interests, and levels of achievement. New educational instruments and techniques have been invented in a scientific attempt to discover and measure these differences. The unreliability of the old essay type of examination is manifest when one tries to use it to compare school to school, course to course, teacher to teacher and one group of students to another. For these purposes the newer or objective type of examination is considered better. Although difficult to make, it is fairer because of the broader sampling involved, the limits of a knowledge are determined more accurately, they can be marked objectively and mechanically, only one correct answer to a question is possible, and they are compiled by experts in designing examinations after conference among themselves—so they do not reflect the queries of only one examiner. It is claimed

that the reliability, validity and correlation factors are high in this type of examination. To the statement that reasoning is not measured as much as is memory, the advocates of the newer examinations enter a vigorous denial; the newer type has memory and thinking so interwoven they cannot be separated. Nevertheless the essay type does have its place, especially for work in organizing material. The administration of such tests at Denison from the time a student applies for admission until late in his college course was described. Among the possible extensions of the service might be listed (a) ratings of students to determine fitness to enter upper classes, (b) corrective work in English, (c) use to discourage those who seek "grades" only—not real attainment, (d) separation of "Honor" from "Pass" students, (e) permit greater specialization in fewer subjects, (f) enable better students to speed up their work, (g) comparison of our own grading standards with those from other (newer) tests. On the whole such tests have evidenty proved their worth at this institution.

April 28, 1942

VARIATIONS OF THE POSTERIOR VENA CAVA IN MAN AND IN THE CAT, AND THEIR POSSIBLE EXPLANATION. G. D. MORGAN.

Variations in the anatomy of animals are quite common. Thus, the positions assumed by organs, their sizes, sometimes their numbers are not identical in all individual of a species. What are the explanations of these atypical conditions? Possibly abnormalities of environment, e.g, oxygen supply, interference with the axis of growth, variations in the circulatory system, etc. In the case of the venous system posterior to the heart a large number of variations are known; of these at least 15 types of variation in the cat are recorded, and illustrations of many of these were presented and reasons for them advanced.

May 11, 1942

At the final business session of the college year 1941–1942 officers were elected as follows:

W. A. Everhart, *President*
R. H. Mahard, *Vice-President*
C. S. Ades, *Recording Secretary and Treasurer*
W. C. Ebaugh, *Permanent Secretary and Editor*
L. E. Smith, *Librarian*

In accordance with the usual custom three numbers of the JOURNAL OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY were published during the college year 1941–1942, *viz.*:

Vol. 36, Articles 4–5, pp. 67–132, August, 1941
What Students Want in an Instructor; L. C. Steckle. 4 pp.
Chemistry and Modern Laundry Practice; Earl R. Haynes. 63 pp., 3 figs.
Vol. 36, Articles 6–8, pp. 135–174, December, 1941
Illinoian Glaciation in Killbuck Valley South of Millersburg, Ohio; George D. Hubbard. 11 pp., 1 fig.
Biological Sociology; Alfred Edwards Emerson. 10 pp.

Denison University acted as host to the Ohio Academy of Science for its Spring Meetings. An outline of the events is presented in the following excerpt from the report of A. W. Lindsey, Secretary.

"The fifty-second meeting of the Academy took place in Granville on April 16, 17 and 18, 1942. Although the date was originally set as the first weekend in May and was changed to avoid conflict with the Baltimore meeting of the American Physical Society, the change was very probably an advantage, for the weather was perfect. The Academy had not met in Granville for twenty-nine years. In that period it had grown beyond the capacity of the available accommodations, but the addition of the new Life Science Building to the Denison University campus provided ample rooms for all sectional meetings this year.

The session opened with the annual meeting of the Executive Council at 3:30 P.M., April 16. This meeting is reported on another page.

Thursday evening the Academy presented Mr. Karl Maslowski, of Cincinnati, in his illustrated lecture, *From Seashore to Glacier with a Naturalist*. Mr. Maslowski's genial personality and superlative motion pictures in color provided an evening's entertainment that has brought many expressions of enthusiastic appreciation from his capacity audience.

Friday, April 17, was given over wholly to sectional meetings and the annual banquet and business meeting. With the exception of the Physics section and the Junior Academy, which met on the following day, each of the nine remaining sections met for one or both morning and afternoon sessions. In general the attendance was large.

The newly formed Section K, Anthropology, with an initial membership of 17, also joined the Academy on this occasion. Their enthusiasm deserves the congratulations and good wishes of our entire membership as we welcome them into our organization.

The ladies of Denison University received the ladies of the Academy at tea in Curtis Hall during the late afternoon, and the perfect spring day led many of the members to spend their spare time out of doors. It is difficult for a secretary who is also connected with the host institution to express himself properly on the occasion. From the many complimentary remarks that have come in, Academy visitors evidently found the day most enjoyable, and from the Secretary's local role he can testify that no visitor could have been more pleased than the committee on arrangements that the campus and the weather did their part so well!

The banquet was served in the Granville Inn to a group of approximately 150. Dr. W. C. Ebaugh, chairman of the local Committee on Arrangements, presided as toastmaster. Following the banquet President Kenneth Irving Brown of Denison spoke briefly in welcome. His remarks on the budget items requested by scientists brought a hilarious moment into the meeting. Dr. George B. Barbour, Dean of McMicken College of Liberal Arts of the University of Cincinnati, responded in kind for the Academy, demonstrating brilliantly that scientists need not be only scientists but may be versatile scholars as well.

The program concluded with the address of President Eugene Van Cleef of the Academy on *The City of the Future*, in which an interesting picture was painted of the effects of air transportation and commercial needs on city planning in times to come.

In the brief business meeting following the banquet, the proposed changes in the Constitution, approved by the Council, were ratified by the Academy. In lieu of a report of the Committee on Necrology, which had just been appointed, the Secretary read the names

of the members who had passed away during the year. These names were referred to the Committee for their action.

The report of the Council, presented by the Secretary, showed the addition of 26 new members. . . .

Dr. J. Paul Visscher presented the report of the Committee on Resolutions, and after a vote of approval the meeting adjourned.

Respectfully submitted,
A. W. LINDSEY, *Secretary.*

The format of our JOURNAL OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY was changed with the initial number of Volume 37 (April, 1942). By this alteration economies in costs are effected without loss of ease of reading or general typographical excellence.

With the increased strain upon shipping and industrial life brought about by the war it is evident that all countries affected are having trouble in maintaining scientific activities and the exchange of publications. During the year many requests have been received that we hold copies of our JOURNAL OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY until after the close of the war. This we are doing, and shipment will be made as soon as conditions warrant. Our files are kept intact.

With rising costs, many of our exchanges have found it necessary to suspend publication or to retrench greatly; with our own JOURNAL we hope to continue issuing it three times a year in accordance with our usual custom, but it may be necessary to limit strictly the number of pages printed.

With the entrance of many of our members and contributors into war activities the amount of material received for publication is bound to diminish. This unfortunate effect of the war is unavoidable.

The Association extends its thanks to Denison University, its Board of Trustees and Administrative Officers for their continued support of its activities.

Respectfully submitted,
W. C. EBAUGH, *Permanent Secretary and Treasurer*

SUBJECT AND AUTHOR INDEX

Ordovician and Silurian of American Arctic and Subarctic Regions; Aug. F. Foerste. 54 pp., 2 plates.
Location Factors in the Iron and Steel Industry of Cleveland, Ohio; Charles Langdon White. 16 pp., 4 figs., 1 plate.
A Photographic Record of the Total Eclipse of the Moon; Paul Biefeld. 2 pp., 1 plate.
Basslerina, A New Holliniform Ostracode Genus, with Description of New Pennsylvanian Species from Texas and Oklahoma; Raymond C. Moore. 15 pp., 3 plates.

Articles 6–9, pp. 115–264, August, 1929 .... $1.50
Some Proparia from the St. Clair Limestone, Arkansas; Norman L. Thomas. 14 pp., 2 plates.
Cephalopods of the Red River Formation of Southern Manitoba; Aug. F. Foerste. 107 pp., 29 plates.
A Large Fish Spine from the Pennsylvanian of North Central Texas; Raymond C. Moore. 7 pp., 1 plate.
Location Factors in the Iron and Steel Industry of the Buffalo District, New York, Charles Langdon White. 20 pp., 6 figs.

Articles 10–13, pp. 265–427, December, 1929 .... $1.50
Three Studies of Cephalopods; Aug. F. Foerste. 117 pp., 23 plates.
A New Genus of Mosasaurs from Mexico, and Notes on the Pelvic Girdle of Platecarpus; M. G. Mehl. 18 pp., 5 figs., 4 plates.
Stream Piracy near Asheville, N. C.; Frank J. Wright. 6 pp., 1 fig., 1 plate.
Motor Vehicle Transportation Cost and its Relation to Highway Finance; Bruce D. Greenshields. 6 pp., 1 fig.

VOLUME 25

Articles 1–3, pp. 1–164; April, 1930 .... $1.50
Port Byron and Other Silurian Cephalopods; Aug. F. Foerste. 124 pp., 2 figs., 25 plates.
The Iron and Steel Industry of Youngstown, Ohio; Charles Langdon White. 22 pp., 7 figs.
New Species of Bryozoans from the Pennsylvanian of Texas; Raymond C. Moore. 17 pp., 1 plate.

Articles 4–5, pp. 165–200, August, 1930 .... $1.00
Visual Localization in the Horizontal Plane; Winford L. Sharp. 9 pp.
Petroleum Products for Internal Combustion Engines; Milton Finley. 26 pp., 3 figs.

Articles 6–7, pp. 201–299, December, 1930 .... $1.00
The Actinoceroids of East-Central North America; Aug. F. Foerste and Curt Teichert. 96 pp., 33 plates.
The Presence of Nybyoceras in South Manchuria; Riuji Endo. 3 pp., 1 plate.

VOLUME 26

Article 1, pp. 1–142; April, 1931 .... $1.50
The Hesperioidea of North America; A. W. Lindsey, E. L. Bell and R. C. Williams, Jr. 142 pp., 33 plates.

Article 2, pp. 143–250; December, 1931 .... $1.50
The Older Appalachians of the South; Frank J. Wright. 108 pp., 38 plates.

VOLUME 27

Article 1, pp. 1–46; June, 1932 .... $1.50
The Geomorphic Development of Central Ohio (Part I); Henry S. Sharp. 46 pp., 1 fig., 6 plates.

Article 2, pp. 47–136; December, 1932 .... $1.50
Black River and Other Cephalopods from Minnesota, Wisconsin, Michigan, and Ontario (Part I); Aug. F. Foerste. 90 pp., 31 plates.

VOLUME 28

Articles 1–3, pp. 1–154; April, 1933 .... $1.50
Black River and Other Cephalopods from Minnesota, Wisconsin, Michigan, and Ontario (Part II); Aug. F. Foerste. 146 pp.; for plates *cf.* This Journal, Vol. 27, Art. 2 (December, 1932).
A Study of the Change in Mass of the Anode of the Aluminum-Lead Cell; Charles E. Welling. 5 pp.
Balancing Chemical Equations—The Contribution of Otis Coe Johnson (1880); W. C. Ebaugh. 4 pp., 1 plate.

Article 4, pp. 155–248; October, 1933 .... $1.00
The Ordos Desert of Inner Mongolia; George B. Cressey. 94 pp., 32 figs., 1 plate.

VOLUME 29

Article 1, pp. 1–105, April, 1934 .... $1.25
The Newer Appalachians of the South (Part I); Frank J. Wright. 105 pp., 28 plates, 3 figs.

Article 2, pp. 107–193, August, 1934 .... $1.25
Silurian Cyrtoconic Cephalopods from Ohio, Ontario, and Other Areas; Aug. F. Foerste. 86 pp., 14 plates.

Articles 3–4, pp. 195–238, December, 1934 .... $1.00
Evidence of Ice Action in the Teays Valley, West Virginia; Julian J. Petty. 10 pp., 4 figs.
The Earlier History of the BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY; Aug. F. Foerste. 23 pp.

VOLUME 30

Articles 1–2, pp. 1–118, April, 1935 .... $1.00
Big Horn and Related Cephalopods; Aug. F. Foerste. 96 pp., 22 plates.
New Light Sources for Photographic Purposes; W. E. Forsythe. 22 pp., 7 figs.

Articles 3–4, pp. 119–230, August, 1935 .... $1.00
Correlation of Silurian Formations in Southwestern Ohio, Southeastern Indiana, Kentucky and Western Tennessee; Aug. F. Foerste. 87 pp.
A Study of the Phenomenon of Wetting Films; C. W. Chamberlain and Kenneth Lyle Warren. 25 pp., 4 plates, 1 fig.

Articles 5–6, pp. 231–303, December, 1935 .... $1.00
The Cephalopods of the Maquoketa Shale of Iowa; Aug. F. Foerste. 27 pp., 11 plates.
New Genera of Ozarkian and Canadian Cephalopods; E. O. Ulrich and Aug. F. Foerste. 32 pp., 1 plate.

VOLUME 31

Articles 1–2, pp. 1–92, April, 1936 .... $1.00
Hierosaurus colei; a new aquatic Dinosaur from the Niobrara Cretaceous of Kansas; M. G. Mehl. 20 pp., 3 plates.
Silurian Cephalopods of the Port Daniel Area on Gaspé Peninsula, in Eastern Canada; Aug. F. Foerste. 72 pp., 23 plates.

Article 3, pp. 93–142, August, 1936 .... $1.00
The Newer Appalachians of the South (Part II): South of the New River; Frank J. Wright. 50 pp., 6 figs., 32 plates.

Articles 4–6, pp. 143–259, December, 1936 .... $1.00
A Study of the Vestigial Air Bladder in the Darter (*Catonotis flabellaris rafinesque*); George David Morgan. 16 pp., 10 plates.
We Must Shape our New World (Commencement Address); Arthur Holly Compton. 11 pp.
Later History of the JOURNAL OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY; Kirtley F. Mather. 25 pp.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION. 52 pp.

VOLUME 32

Articles 1–2, pp. 1–131, April, 1937 .... $1.00
History of *Theta* Chapter of Ohio, Phi Beta Kappa (1911–1936); Willis A. Chamberlin. 69 pp., 2 figs.
The Tungsten Filament Incandescent Lamp; W. E. Forsythe and E. Q. Adams. 72 pp., 10 figs.

Articles 3–7, pp. 133–207, August, 1937 .... $1.00
Science and the College (Commemoration Address); Carey Croneis. 12 pp.
Our Endowment (Commemoration Address); C. Judson Herrick. 9 pp.
Science—Man's Liberator (Commemoration Address); William E. Wickenden. 10 pp.
The Application of Physics to Modern Hydrographic Surveying; (Commemoration Address); Herbert Grove Dorsey. 22 pp., 10 plates.
An Annoted Check-list of Birds Recorded at Granville, Licking County, Ohio; Ward M. Klepfer and William J. Taylor. 21 pp., 1 plate.

Article 8, pp. 209–337, December, 1937 .... $1.00
Upper Carboniferous Crinoids from the Morrow Subseries of Arkansas, Oklahoma and Texas; Raymond C. Moore and Frederick N. Plummer. 106 pp., 37 figs., 5 plates.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION. 10 pp.

VOLUME 33

Article 1, pp. 1–60, April, 1938 .... $1.00
The Telescopic Alidade and the Plane Table as used in Topographic and Geologic Surveys; Kirtley F. Mather and Bradford Washburn. 60 pp., 19 figs.

Articles 2–3, pp. 61–155, August, 1938 .... $1.00
Chemistry and the Modern Meat Packing Industry; Minard Patrick. 48 pp., 3 figs.
Certain Nuclear Masses in the Macaque Medulla Oblongata—Preliminary Report; Frederick David Goudie. 47 pp., 8 figs.